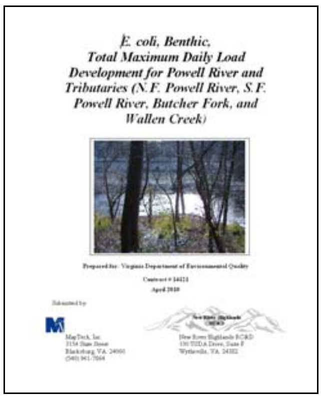
Phase II Benthic TMDL Development for North Fork Powell River, South Fork Powell River, and Powell River


E. coli, Benthic, Total Maximum Daily Load Development for Powell River and Tributaries (N.F. Powell River, S.F. Powell River, Butcher Fork, and Wallen Creek)

Powell River	*from Roaring Branch to Big Stone Gap*
Powell River	*from Poor Valley Creek to Public Water Supply (river mile 161.62).*
Powell River	*from Hardy Creek to Yellow Creek.*
N. Fk Powell R.	*from Straight Creek to the Powell River*
S. Fk Powell R.	*from Butcher Fork to the Powell River*
S. Fk Powell R.	*from Beaverdam Creek to Butcher Fork*

Prepared for:

Virginia Department of Environmental Quality

and

Virginia Department of Mines, Minerals and Energy

Contract # C116062

October 2013

Submitted by:

MapTech, Inc.
3154 State Street
Blacksburg, VA 24060
(540) 961-7864

Page intentionally blank

TABLE OF CONTENTS

FIGURES

TABLES

Page intentionally blank

1. INTRODUCTION

In order to meet the U. S. Environmental Protection Agency's (EPA) May 1, 2010 deadline, Virginia agencies produced Total Maximum Daily Load (TMDL) studies for the Levisa Fork River, Bull Creek, North/South Fork of the Pound River, and Powell River. During development, uncertainties regarding data and predictive tools were identified and help with the TMDL was solicited. The U. S. Office of Surface Mining, U.S. EPA, and private contractors provided assistance, but some concerns regarding the sufficiency of the available data's ability to determine pollution load reductions and the adequacy of the predictive tools being utilized remained. Therefore, the TMDL reports were submitted to EPA as "Phased" TMDLs in accordance with EPA guidance with the understanding that the Commonwealth of Virginia would utilize an adaptive management approach to complete the TMDLs.

Revised TMDL documents were planned for submittal to EPA two years from the date that both the U.S. EPA Region III approved and the Virginia State Water Control Board (SWCB) adopted the "phased" TMDLs. The Virginia Department of Mines, Minerals, and Energy's Division of Mined Land Reclamation (DMLR) took the lead role with the revisions. The issuance of the phased TMDLs was intended to provide time to address uncertainties with the individual TMDLs and to make any necessary revisions while interim water quality improvements were initiated.

To support TMDL completion, a monitoring plan and experimentation for model refinement was implemented by the Virginia Department of Environmental Quality (DEQ) and DMLR during the period of time beginning with the submittal to EPA of the DRAFT Phased TMDLs.

Although additional monitoring data, modeling refinements, allocations for pollutants, and long term implementation actions were expected in the revised TMDLs, on-going, long-term efforts to improve the watershed continued. In the interim, DMLR utilized its existing TMDL processes and software to maintain or decrease existing pollution wasteloads from active mining for TSS and TDS. DMLR also restricted additional mining, through the use of offset requirements.

A number of questions have been identified regarding data needs for these Phased TMDLs. These questions were the basis for the monitoring plan design.

Addenda (Phase II TMDLs) for the Bull Creek, Levisa Fork, Pound River, and Powell River Phased TMDLs have been developed to complete work on all four TMDLs.

1.1 Phased TMDLs in the Powell River Watershed

In addressing provisions of the Clean Water Act and agreements with the United States Environmental Protection Agency, Virginia's Department of Environmental Quality initiated the TMDL development process for six aquatic life impaired segments in the Powell River Basin in the area of Appalachia, Big Stone Gap and Jonesville, Virginia. MapTech, Inc. provided contract assistance by performing the analyses, modeling, and report preparation. During TMDL development, uncertainties and differences of interpretation regarding report narrative, report format, data, and predictive tools were identified. Additional monitoring, analysis, and model refinement was planned to resolve the uncertainties and differences. Upon resolution of the questions to the satisfaction of the interested parties, the phased TMDLs are being completed in the form of this addendum to the phased TMDL.

In these Powell River impairments, excessive sediment loadings to the streams were found to be the most probable stressor to the aquatic community. The possibility arose that polynuclear aromatic hydrocarbons (PAHs) in streambed sediments were a stressor on the benthic macroinvertebrate community as well. However, there was some question as to whether these PAHs were bioavailable, and therefore, whether they should be considered as a likely stressor. Specific concerns about sediment calculations focused on the estimated load from control ponds at active mines during storm events, and the estimated load from ancillary active mining areas. Ancillary areas are active mining areas that are not controlled by ponds, Abandoned Mine Lands (AML), as well as reclaimed and released areas.

The resulting TMDL document was submitted to VADEQ in April 2010, and was titled *E. coli, Benthic, Total Maximum Daily Load Development for Powell River and Tributaries (N.F. Powell River, S.F. Powell River, Butcher Fork, and Wallen Creek)*. The stressor analysis found that napthalene exceeded the Consensus Probable Effect Concentration (PEC) and 2-methyl napthalene exceeded the Virginia 99th percentile screening values for sediment. No other PAHs exceeded PEC or Virginia 99th percentile screening values in the impaired segments that were the focus of this TMDL. Although the phenanthrene concentration in a sample collected on the

Powell River (6BPOW179.20) on 1/26/2006 was 1,048 ug/Kg (PEC value is 1,170 ug/Kg) and it exceeded the PEC value in a sediment sample collected on Looney Creek (1,300 ug/Kg) on 6/3/2009. Looney Creek is also a small tributary to the Powell River.

The dominant form of PAHs found throughout the watershed were forms of naphthalene, a highly volatile substance. Naphthalene is found in mothballs & moth flakes, tar camphor, coal, and petroleum. It is also a byproduct of burning wood and fossil fuels. Naphthalene is usually gone from rivers or lakes within two weeks. It binds very weakly to soil and sediments. This suggests two possibilities. Either an active, widely distributed source of naphthalene exists in the watershed, or naphthalene in the sediments is bound-up tightly, perhaps in coal sediments. Given conditions in the watershed, the second scenario seems the most likely. If this is the case, then there is a question of whether the tightly bound naphthalene is bio-available.

A monitoring plan was developed to gather additional information on sediment (TSS) loads from surface mine ponds, and the role of PAHs as stressors to benthic macroinvertebrate community in the Powell River watershed. This document addresses the findings of the additional data collection, and resulting adjustments to the TMDL.

Page intentionally blank

2. MONITORING TO SUPPORT PHASE II TMDLS

A monitoring plan was developed and executed to support Phase II TMDL development. For the Powell River TMDL, the pollutants of concern were TSS (sediment) and PAHs.

2.1 TSS (Sediment) Monitoring

The goal of the TSS monitoring project, was to better quantify sediment contributions to the watershed from active mining operations during larger storm events. More specifically, the questions addressed were:

- What is the best approach for representing existing contributions from permitted mining discharges?

- What is the best approach for representing allocated loads (*i.e.*, waste load allocations – WLAs) from permitted mining discharges?

The full report on the sediment monitoring effort and analyses is included in Appendix A (Representation of TSS Loads in Coalfield TMDLs). The results indicated that existing TSS loading from actively mined areas may have been moderately underestimated in the Phase I TMDL, however, the modeling of the TMDL was validated.

The recommended approach for estimating both existing and allocated loads from permitted surface mine discharges is to use the maximum permitted concentration (70 mg/L) applied to the runoff volume from active mine (disturbed) areas.

2.2 PAH Monitoring

A study was conducted by Biological Monitoring, Inc. of Blacksburg, VA to determine if various PAH compounds were bioavailable (accumulating in the tissues of aquatic organisms). The study incorporated the USEPA bioaccumulation study guidelines. The monitoring plan recommended the use of benthic macroinvertebrates and mussels for the study. The monitoring plan identified five locations sampling (**Figure 2.1**). Three of the sites had naphthalene above the PEC in the streambed sediment (High Level). Two of the sites had naphthalene below the PEC (Low Level).

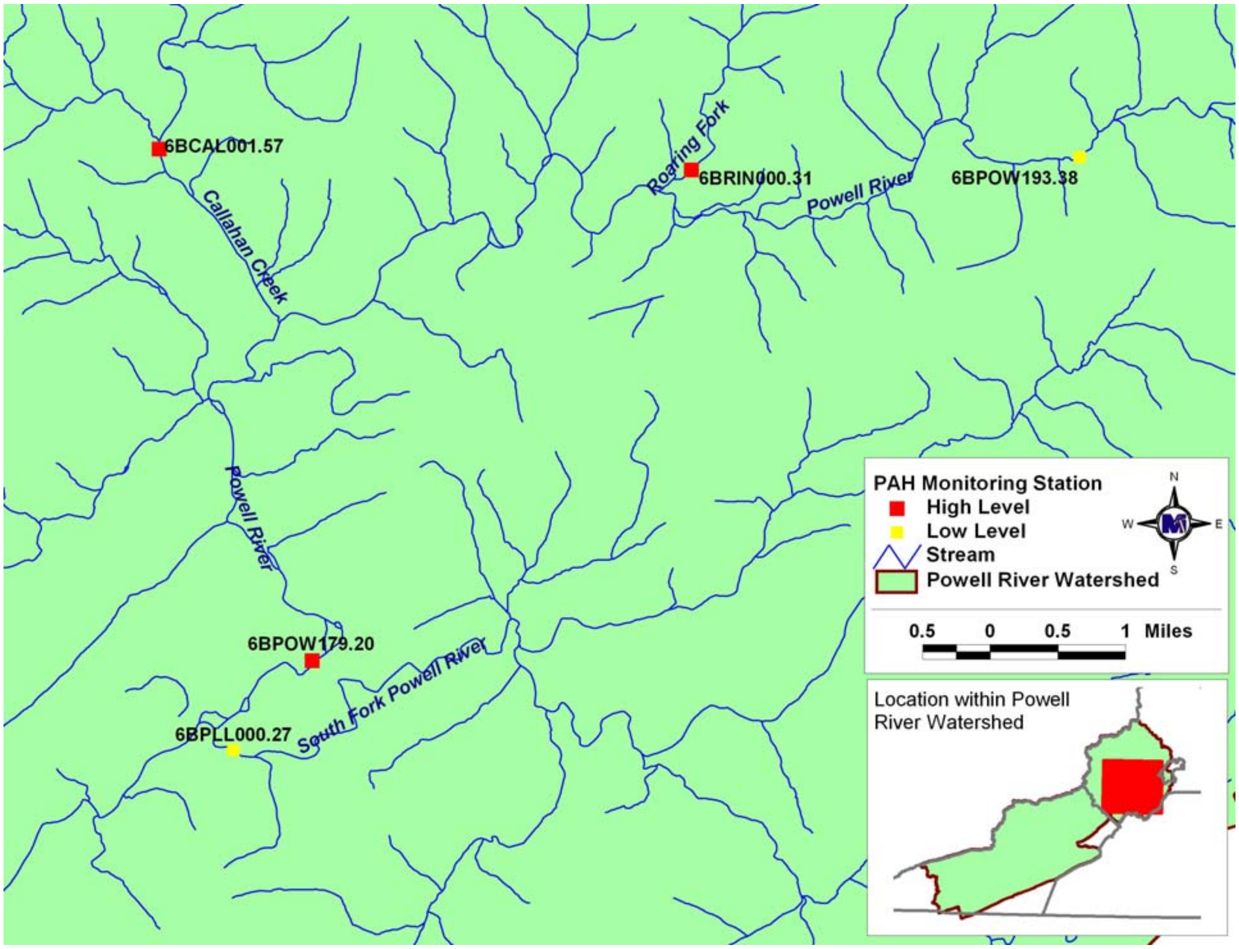


Figure 2.1 Sample locations for PAH (naphthalene) bioavailability study.

Benthic macroinvertebrate collections began in November 2012. The tissues of biota collected from each site were analyzed for PAHs. A mussel species, the wavy-rayed lampmussel (*Lampsilis fasciola*), was incorporated into the study. Silos, with mussel specimens, were installed at the established monitoring sites for the successful retrieval of the mussels at the completion of the study. The mussels remained in the silos for two months (11/28/12 – 1/29/13) and were 20 to 25 mm in length. The tissues of these mussels were analyzed for PAHs as well.

The results indicated that neither naphthalene nor 2-methyl naphthalene were detected in the composited tissues of either the benthic macroinvertebrates or the wavy-rayed lampmussels at any of the sites. However, three PAH compounds were detected in the benthic macroinvertebrate samples from two of the five monitoring sites. Fluoranthene and phenanthrene were detected at the Callahan Creek monitoring site. Pyrene was detected at the

Callahan Creek and a Powell River site (the specific concentration reported at the Powell River site was an estimate).

Benzo(a)pyrene and indeno(1,2,3-cd)pyrene were detected in the wavy-rayed lampmussel samples. Benzo(a)pyrene was detected in the mussel tissue from three different stations (Powell River, Callahan Creek and S.F. Powell River). Indeno(1,2,3-cd)pyrene was found in mussel tissue samples from the Callahan Creek, South Fork Powell, and Powell River stations.

Based on this study, there is not sufficient evidence to conclude that PAHs should be elevated to a “Most Probable Stressor” in the TMDL. This is based primarily on the fact that naphthalene and 2-methyl naphthalene were not found in any of the samples. The PAH compounds that were detected had sediment concentrations below their recommended PEC concentration at those sites. In addition, the fact that some PAH compounds were found in the tissue samples does not confirm that they would have lethal or sublethal impacts on the organisms.

However, it is recommended that PAHs remain as a “Possible Stressor” in the Powell River TMDL at this time. The TMDL discussed the fact that the Clinch and Powell river basins support more threatened and endangered aquatic species (primarily mussels) than almost any other basin in North America. The degree of loss is unprecedented among other wide-ranging faunal groups in North America and is therefore of national significance. The fact that PAH compounds were detected in the mussel samples is of concern. A study published by the Society of Environmental Toxicology and Chemistry (SETAC) in January 2013 provided some new insights into the possible impact of PAHs on benthic macroinvertebrates and mussels (SETAC, 2013[1]).

Toxicity studies were performed on whole sediment samples collected from watersheds impacted by coal mining and/or natural gas extraction in the Upper Tennessee River and South Fork Cumberland River Basins in Tennessee and Virginia. The organisms used were an amphipod (*Hyalella azteca*), a midge (*Chironomus dilutus*) and two mussels, the rainbow mussel (*Villosa iris*), and wavy-rayed lampmussel (*Lampsilis fasciola*). PEC concentrations for metals and

[1] Environmental Toxicology and Chemistry, Volume 32, Issue 1, January 2013, Pages: 207–221, Ning Wang, Christopher G. Ingersoll, James L. Kunz, William G. Brumbaugh, Cindy M. Kane, R. Brian Evans, Steven Alexander, Craig Walker and Steve Bakaletz. Article first published online : 26 NOV 2012, DOI: 10.1002/etc.2032

PAHs were below published PEC levels in the sediment samples. The results found impacts on the mussels at much lower concentrations than the benthic macroinvertebrates. Concentrations that caused sublethal impacts on the growth of the mussels were significantly lower than lethal concentrations. Because there was a direct correlation between metals, PAHs and major ions the researchers were not able to determine which group of pollutant and/or combinations were responsible for the toxicity. The mussels used in this study were only 1 mm in size which may be the most critical life stage for mussels. Mussels this young must burrow into the sediment to feed and are therefore exposed to the higher pollutant concentrations contained in the sediment pore water. Once mussels exceed 3 mm in length they begin feeding that the boundary of the stream and sediment layer where pollutant concentrations are expected to be lower. Mussels only 1 mm in size are difficult to retrieve in laboratory studies and it might not be possible to use them in in-stream containment studies.

Additional studies are needed to determine which pollutant or group of pollutants may be impacting the juvenile mussels. The results of this laboratory study do not provide sufficient evidence to justify elevating PAHs to a “Most Probable Stressor” status in the Powell River TMDLs but do raise additional concerns over their potential impacts on aquatic life.

3. ADJUSTMENTS TO PHASE I MODEL

No adjustments were made to the modeling for the TMDL calculations. PAHs remain a "Possible Stressor" for the Powell and North Fork Powell Rivers and therefore required no additional modeling. The TSS modeling for TMDL calculations was validated. However, the calculation of existing loads from permitted sources did change. Specifically, existing loads from permitted surface mine discharges were originally estimated using long-term monitoring data to calculate flow-weighted average TSS concentrations, and apply them to flow volumes modeled from active mine (disturbed) areas. These long-term average concentrations are, typically, less than the permitted 70 mg/L. This approach appears to have been biased low. The recommended approach is to use the maximum permitted concentration (70 mg/L) applied to the runoff volume from active mine (disturbed) areas. **Table 3.1** is a revisionss of **Table 12.2** from the Phase I TMDL document, presented with the original values struck-through and columns added to indicate revised loads.

Table 3.1 Existing and allocated annual sediment loads for DMME mining permits within the Powell River watershed.

DMME Mine Permits[1]	~~Existing Load t/yr~~	~~Allocated Load t/yr~~	Existing/Allocated Load t/yr	DMME Mine Permits	~~Existing Load t/yr~~	~~Allocated Load t/yr~~	Existing/Allocated Load t/yr
1100033	~~24.51~~	~~41.25~~	41.25	1201921	~~0.41~~	~~0.69~~	0.69
1100439	~~5.96~~	~~10.03~~	10.03	1201949	~~0.73~~	~~1.23~~	1.23
1100583	~~4.01~~	~~6.75~~	6.75	1202015	~~0.19~~	~~0.32~~	0.32
1100584	~~0.49~~	~~0.83~~	0.83	1301430	~~0.29~~	~~0.49~~	0.49
1100735	~~2.27~~	~~3.81~~	3.81	1301533	~~1.64~~	~~2.77~~	2.77
1100877	~~4.6~~	~~7.74~~	7.74	1301561	~~1.41~~	~~2.38~~	2.38
1101350	~~8.9~~	~~14.97~~	14.97	1301590	~~0.55~~	~~0.92~~	0.92
1101554	~~1.82~~	~~3.07~~	3.07	1301687	~~7.19~~	~~12.10~~	12.10
1101565	~~2.09~~	~~3.52~~	3.52	1301742	~~0.23~~	~~0.38~~	0.38
1101661	~~10.77~~	~~18.12~~	18.12	1301942	~~0.21~~	~~0.36~~	0.36
1101760	~~45.21~~	~~76.06~~	76.06	1301992	~~0.56~~	~~0.94~~	0.94
1101800	~~5.37~~	~~9.04~~	9.04	1402032	~~1~~	~~1.69~~	1.69
1101804	~~25.03~~	~~42.12~~	42.12	1500090	~~0.74~~	~~1.24~~	1.24
1101813	~~8.76~~	~~14.74~~	14.74	1501065	~~14.36~~	~~24.16~~	24.16
1101824	~~2.6~~	~~4.37~~	4.37	1501778	~~43.35~~	~~72.93~~	72.93
1101905	~~24.3~~	~~40.88~~	40.88	1501947	~~1.79~~	~~3.01~~	3.01
1101918	~~14.64~~	~~24.64~~	24.64	1600876	~~11.11~~	~~18.70~~	18.70
1101954	~~34.98~~	~~58.85~~	58.85	1601423	~~6.05~~	~~10.18~~	10.18
1101975	~~8.94~~	~~15.04~~	15.04	1601466	~~29.89~~	~~50.30~~	50.30
1101991	~~9.43~~	~~15.87~~	15.87	1601486	~~32.17~~	~~54.13~~	54.13
1102011	~~9.8~~	~~16.49~~	16.49	1601519	~~4.4~~	~~7.40~~	7.40
1102028	~~10.72~~	~~18.05~~	18.05	1601576	~~38.38~~	~~64.57~~	64.57
1102031	~~1.75~~	~~2.95~~	2.95	1601656	~~2.31~~	~~3.88~~	3.88
1201589	~~0.41~~	~~0.69~~	0.69	1601744	~~32.11~~	~~54.03~~	54.03
1201680	~~0.1~~	~~0.17~~	0.17	1700624	~~1.05~~	~~1.77~~	1.77
1201803	~~0.37~~	~~0.62~~	0.62	1701152	~~0.31~~	~~0.53~~	0.53
1201875	~~0.58~~	~~0.97~~	0.97	1701869	~~1.46~~	~~2.46~~	2.46

[1] This table is a reproduction of Table 12.2 from the Phase I TMDL document. Reformatted for better presentation in this document, and edited based on results of the Phased TMDL assessment.

4. PHASE II TMDLS FOR NORTH FORK POWELL RIVER, SOUTH FORK POWELL RIVER, AND POWELL RIVER (BENTHIC)

Since no changes were made to the modeling approach for calculating the TMDL values, the Phase I allocations stand. The annual TMDL allocations for TSS developed in the Phase I TMDL are listed in **Table 4.1** (a portion of *Table ES.4* from the Phase I TMDL).

Table 4.1 Average annual in-stream cumulative pollutant loads modeled after allocation in the Powell River impairments.

Pollutant	Units	Impairment	WLA[1]	LA	MOS	TMDL	Existing Load	Percent Reduction
Sediment	t/yr	**Powell River Watershed**	1,657.11	55,877.26	*6,392.74*	63,927.11	91,635.50	37.2%

This revised TMDL document (addendum) was developed by the Virginia Department of Environmental Quality (VADEQ) and the Virginia Department of Mines, Minerals, and Energy's Division of Mined Land Reclamation (DMLR). The revision is being submitted to the U.S. EPA following on the U.S. EPA Region III approval and the Virginia State Water Control Board (SWCB) adoption of the "Phase I" Powell River TMDL. DMLR took the lead role with these revisions.

Page intentionally blank

Appendix A

Representation of TSS Loads in Coalfield TMDLs

Page intentionally blank

Phased TMDL Project
Representation of TSS Loads in Coalfield TMDLs

1. BACKGROUND

During development of aquatic life (benthic) TMDLs for Bull Creek, Levisa Fork, Pound River, and Powell River, questions arose regarding the representation of Total Suspended Solids (TSS) loads from permitted mining areas. Due to these questions, as well as other uncertainties and differences of interpretation regarding report narrative, report format, data, and predictive tools, the reports were presented as "phased" TMDLs in accordance with EPA guidance. The TMDL was developed with best available data and information to determine pollution load reductions. Additional monitoring was conducted to aid in resolving the uncertainties in pollutant sources. This report describes the effort to better characterize the TSS (sediment) loads in the models.

The goal of the TSS monitoring project, was to better quantify sediment contributions to the watershed from active mining operations during larger storm events. More specifically, the questions that need to be answered are:

- What is the best approach for representing existing contributions from permitted mining discharges?
- What is the best approach for representing allocated loads (*i.e.*, waste load allocations – WLAs) from permitted mining discharges?

Two approaches have been used for modeling these discharges. The "*Traditional*" approach assumes that the permitted discharges are in compliance with their permits, and that the semi-monthly sampling, required by Virginia's Department of Mines, Minerals, and Energy (DMME) is adequate to describe long-term loading conditions for the discharges in question. The "*Proposed*" approach, assumes that the TSS load from large storm events is not being fully characterized by semi-monthly sampling, with the result that TSS loads from permitted discharges are being under-represented in the TSS TMDL. The TMDLs for the Powell River and Levisa Fork were developed using the *Traditional* approach, while the TSS TMDLs for the Pound River and Bull Creek were developed using the *Proposed* approach.

The difference between these approaches is primarily related to the impact of large storms on sediment delivery from permitted discharges. In order to assess this impact, three sites were identified where auto-samplers, programmed to collect multiple samples during storm events, could be installed. Samples were collected and analyzed for TSS. Stream stage monitors were also installed at these sites, with the intent of estimating flow volumes during storm events. The results were used to assess the overall impact of storm events on TSS loads.

2. SITE SELECTION

Three sites were identified in the Powell River watershed where auto-samplers could be installed on surface mine discharges. The location of these sites is displayed in **Figure 2.1**. The site locations and general conditions of the contributing drainage areas are described in **Table 2.1**. These sites were selected primarily based on being granted permission to access the sites for the purposes of installing and servicing monitoring equipment. As such, there was a reasonable question as to whether they were representative of mine operations in the area. This was evaluated through assessment of land cover conditions in the drainages, as well as analysis of historical water quality data.

Table 2.1 provides a verbal interpretation of land cover, and **Figure 2.2** shows the spatial distribution of the land cover. As it happens, the sites appear to provide reasonable examples of a “worst case” scenario (Outfall A, with significant land disturbance), a “best case” scenario (Outfall B, with large proportion of the drainage reclaimed or undisturbed), and an “average” scenario (Outfall 004, with a significant amount of recently mined, but reclaimed area).

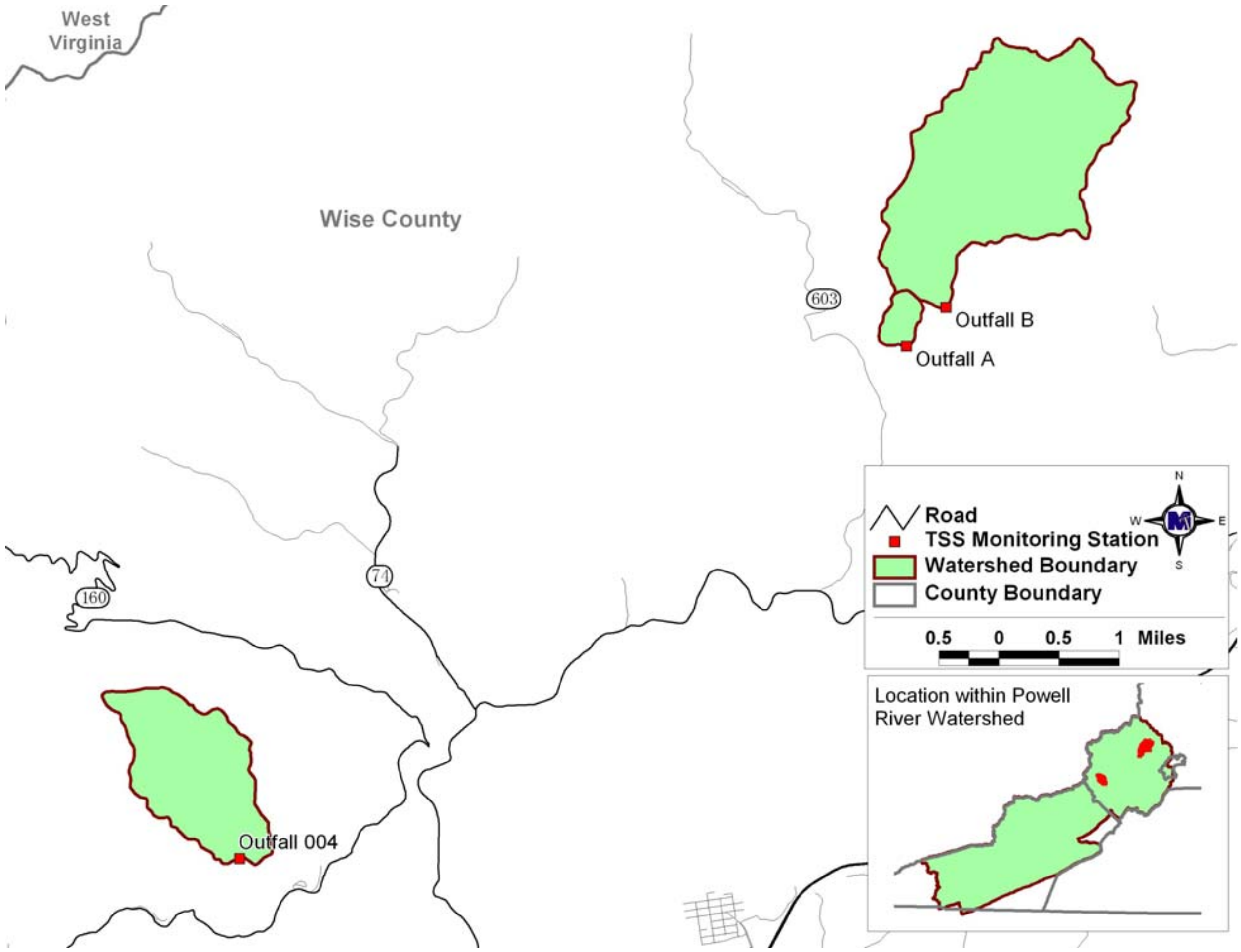


Figure 2.1 Location of Total Suspended Solids (TSS) monitoring sites.

Table 2.1 Description of monitoring sites in the Powell River watershed, where auto-samplers were installed for assessing TSS delivery during storm events.

MPID	Outfall	LAT	LON	Description of Drainage.[1]
0003400	004	36.8878	-82.8179	Approximately 760 acres, on Bearpen Branch, with approximately 30% undisturbed, 65% recently reclaimed, and 5% active mining.
0005433	A	36.9526	-82.7168	Approximately 85 acres, on a tributary to Canepatch Creek, with approximately 5% undisturbed and 95% active mining.
0005578	B	36.9575	-82.7108	Approximately 1,780 acres, on Canepatch Creek (headwaters), with approximately 50% undisturbed, 30% reclaimed, and 20% active mining.

[1] Land cover distribution estimates are based on visual assessment of 2011 aerial photos. "Undisturbed" areas may be reclaimed, but appear to have mature forest cover.

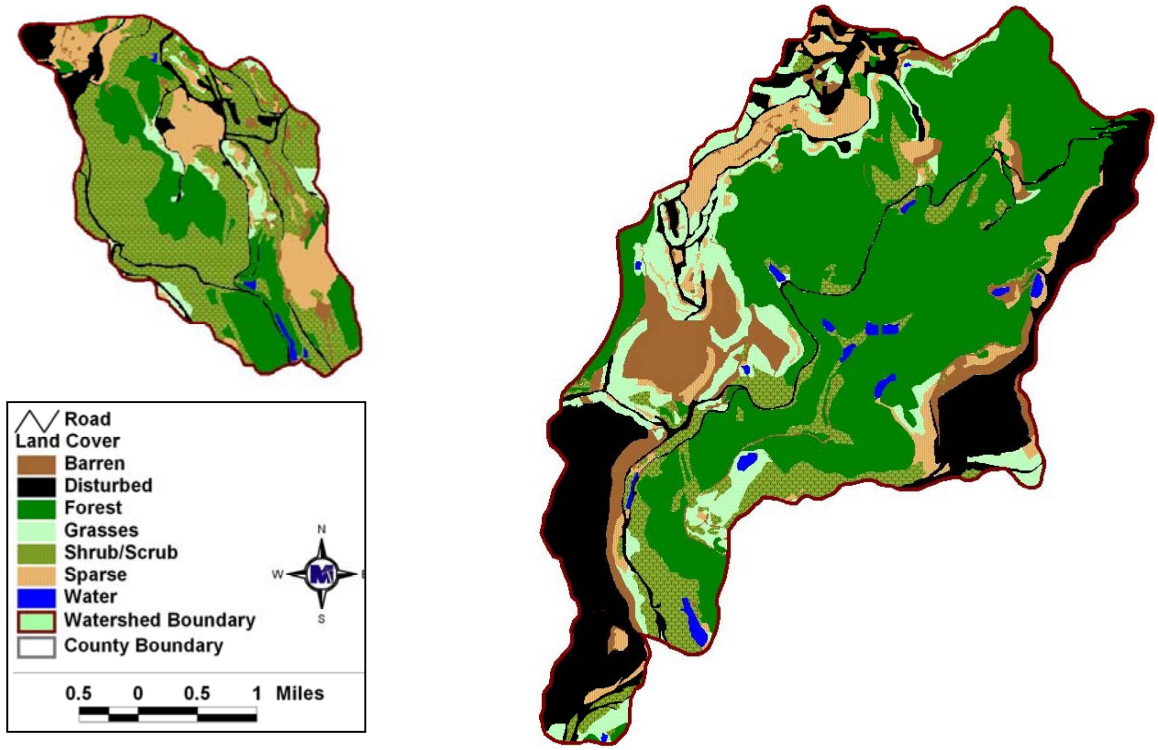


Figure 2.2 Land cover in Total Suspended Solids (TSS) monitoring site drasinages.

Historical monitored data were analyzed to further assess the representativeness of these sites. Samples collected by the permitted mining operators at the three sites were compared with data collected at 424 other permitted sediment control sites in the Powell River watershed. **Figure 2.3** shows a comparison of conditions at permitted surface mine discharges throughout the Powell River watershed. This plot uses all available data from 1987 through 2013. Percentile ranks of the TSS data from the three selected monitoring sites compared favorably with percentile ranks from the remaining permitted sites, especially the 10^{th}, 25^{th}, 50^{th} and 75^{th} percentiles, however, all of the sites in question had lower 90^{th} percentile concentrations. Since the sites in question have only been monitored in more recent years (2005 – 2013), and since sediment delivery can fluctuate widely, dependent on rainfall conditions, it was considered a more evenhanded comparison to only include data collected on the same dates in the comparison. The results of this analysis is presented in **Figure 2.4**. Overall, the sites seem reasonably representative of conditions in the area.

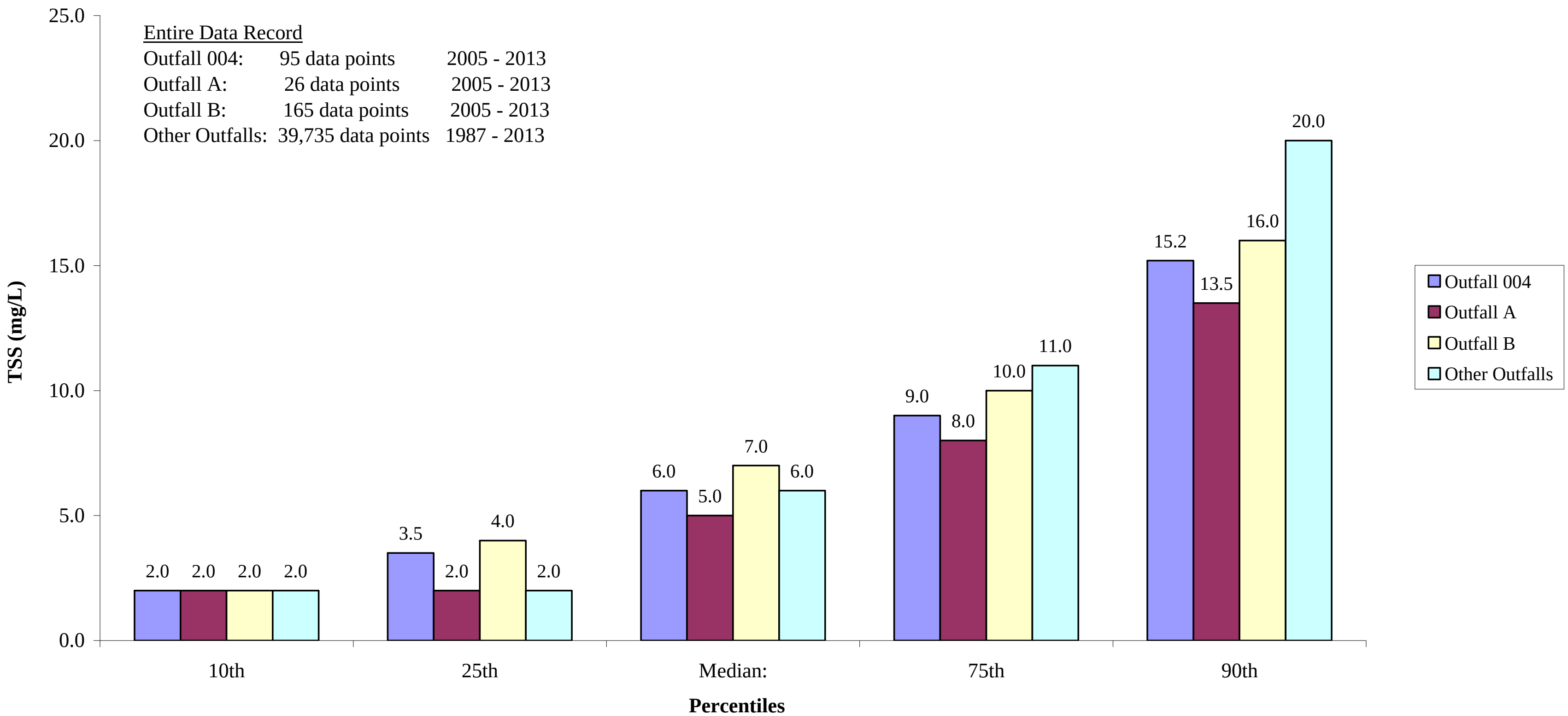


Figure 2.3 **TSS data from selected DMME permitted sites in the Powell River Basin compared to data from all of the remaining permitted sites in the Powell River basin, using all available data from 1987 to the 2013.**

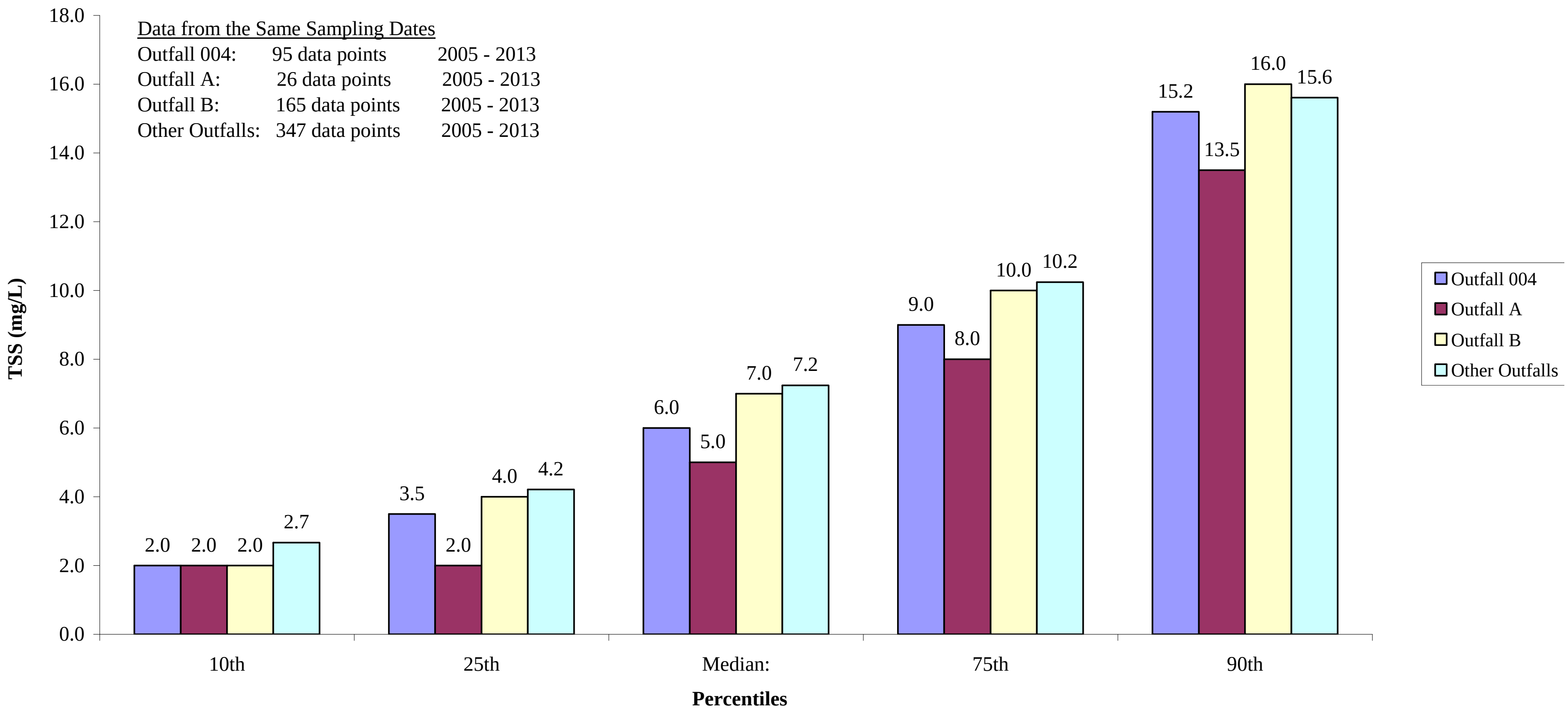


Figure 2.4 TSS data from selected DMME permitted sites in the Powell River basin compared to data from all of the remaining permitted sites in the Powell River basin, on the same monitoring dates.

3. MONITORING DESCRIPTION

The goal of the monitoring effort was to assess the existing monitoring approach, and the model estimates, using a more comprehensive dataset. The focus was on the storm discharge from sediment ponds of active mines. This was accomplished through the use of automated samplers, rain gages, and stream gages. Each sediment sampling station consisted of a data collection platform (DCP) with pressure transducer to record stream levels, an auto-sampler, and a rain gauge (**Figure 3.1**). The automated samplers were configured to collect 24 individual samples during storm events. The samplers used were equipped with a liquid level sensor, which was designed to initiate the sampling routine when the stream level increased by a prescribed amount, as determined through trial and error on site. Upon initiation of a sampling event, sampling occurred at 30-minute intervals for the first 3.5 hours of the event, then continued at 3-hour intervals until all 24 sample bottles were utilized. One sampler was deployed at each of the three sites discussed earlier in this report.

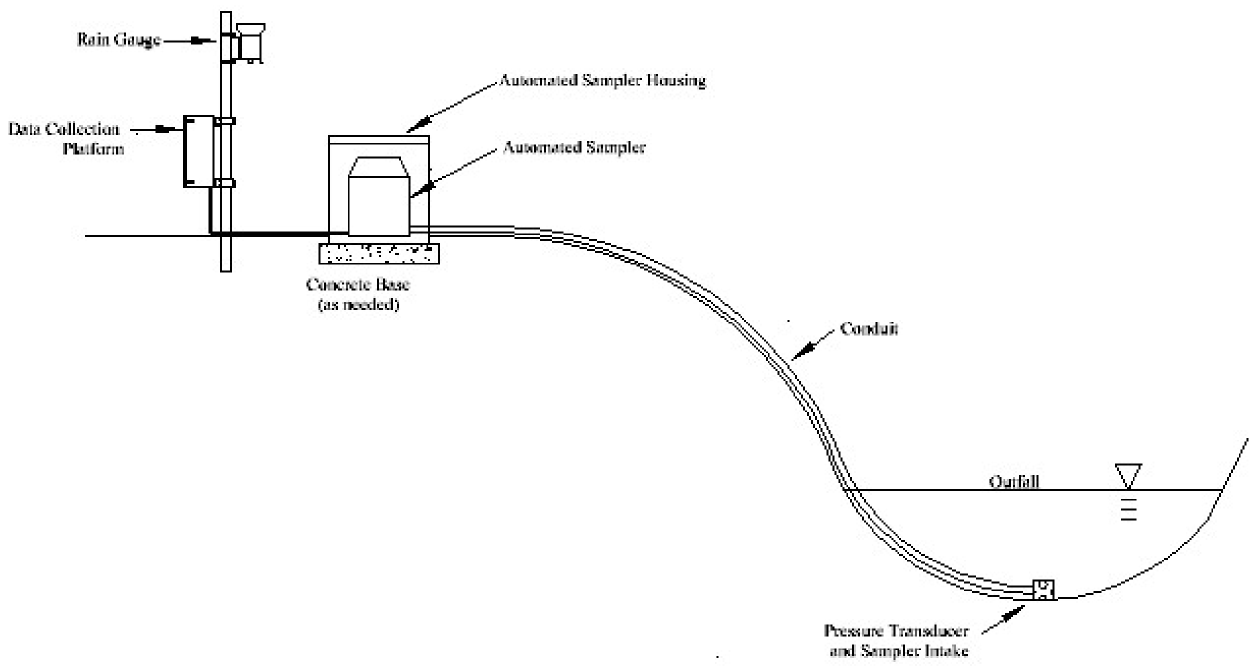


Figure 3.1 Sediment sampling station schematic, showing data collection platform connected to auto sampler, pressure transducer, and rain gauge.

Due to scheduling delays and equipment problems, the stream level measuring equipment (DCP and pressure transducer) were not installed until after the first seven of fourteen sampling events had occurred. One site (Outfall A) was equipped with a compound weir (**Figure 3.2**), to concentrate flow and provide an engineered structure for flow monitoring. Additional equipment malfunctions resulted in data being successfully collected during only four events.

Figure 3.2 Outfall A after weir installation. Data collection platform visible on left. Plastic sheeting is peeled back to expose structure for the photograph.

After each storm event, samples were collected from the auto-samplers and the auto-samplers were reset with new bottles. The collected samples were delivered to the laboratory for processing. The samplers were removed during the month of April while the flow monitoring equipment was being installed. During each site visit, a grab sample was collected and a flow measurement was taken.

4. RESULTS

As discussed earlier in this report, the drainages contributing to these sample sites varied in size and land cover. The effects of these differences can be seen in the flow response. **Table 4.1** shows the results of instantaneous sampling conducted during site visits. These measurements represent base flow conditions at each site. As might be expected, flow volume increases with drainage basin size, but the baseflow TSS concentrations are similar.

Table 4.1 **Instantaneous flow measurements and TSS from grab samples.**

	Outfall 004		Outfall A		Outfall B	
Date	**Flow (CFS)**	**TSS (mg/L)**	**Flow (CFS)**	**TSS (mg/L)**	**Flow (CFS)**	**TSS (mg/L)**
3/4/2013	2.401	------	0.004	------	5.415	------
3/8/2013	------	<5.0	0.13	2.0	7.272	17.0
3/14/2013	2.638	2.0	0.064	2.0	5.288	3.0
3/21/2013	1.292	5.0	0.067	5.0	7.708	7.0
3/28/2013	1.078	<2.0	0.107	<2.0	------	6.0
5/2/2013	1.71	8.0	------	------	5.236	2.5
5/9/2013	1.43	2.0	0.055	6.0	5.973	2.0
5/16/2013	0.869	2.0	0.036	3.0	4.492	6.0
5/23/2013	1.323	6.0	0.017	4.0	4.673	5.0
6/5/2013	0.92	5.0	0.005	<2.0	2.213	2.0
6/11/2013	1.365	8.0	0.095	7.0	8.29	10.0
6/17/2013	0.893	12.0	0.022	7.0	3.352	3.0
6/24/2013	0.919	17.0	0.024	6.0	4.393	11.0
7/1/2013	1.806	7.0	0.108	6.0	9.008	8.0
Average[1]	*1.4*	*6.0*	*0.06*	*4.2*	*5.6*	*6.3*

[1] For the purpose of calculating averages, non-detects were estimated at half of the detection limit.

Preliminary assessment of the TSS data collected from the auto-samplers showed that very few events had TSS values exceeding the 70 mg/L standard (**Table 4.2**). Flow-weighted concentration was only calculated for a limited number of events due to data limitations. Further, flow-weighted concentration calculations were only performed on events associated with outfall A, where the engineered structure (weir) was installed, as the rating curves developed for outfalls B and 004 were not considered accurate enough for use without further data collected for validation. Determining a relationship between rainfall and flow in order to make approximate flow-weighted calculations was unsuccessful. Correlations between TSS and rainfall were also unclear, though various methods were explored.

Six of the seven storm events that resulted in maximum TSS values above the 70 mg/L standard were associated with outfall A. The area that drains to outfall A contains a much higher percentage of recently disturbed land than either of the other two outfalls, so it is not surprising that it should have higher TSS concentrations as well. However, a weir was installed at this site on May 2, 2013, and the response in TSS concentrations to similarly sized storms appeared to have changed after the installation of the weir. This discrepancy led to further analysis.

Table 4.2 Total suspended solids (TSS) and rainfall data from sampling events. Flow-weighted concentration is provided where calculations were possible.

Event Date	Max TSS (mg/L)	Average TSS (mg/L)	Peak 5-min Rainfall (in)	Total Rainfall (in)	Flow-Weighted Concentration (mg/L)
Outfall A (weir site)					
3/5/2013	**150**	41.9	0.04	1.05	
3/11/2013	13	6.0	0.02	0.44	
3/18/2013	**83**	21.7	0.05	0.96	
3/24/2013	55	10.3	0.07	1.06	
5/18/2013*	**75**	22.8	0.20	1.15	31
5/24/2013*	38	9.3	0.04	0.23	13
6/5/2013*	**890**	138.2	0.36	1.11	
6/17/2013*	**317**	49.7	0.09	1.75	
6/27/2013*	**1,250**	243.0	0.16	1.39	685
Outfall B					
3/5/2013	56	23.5	0.04	1.23	
3/11/2013	9	6.8	0.02	0.46	
3/19/2013	19	9.2	0.06	0.94	
3/24/2013	12	6.5	0.07	1.11	
5/5/2013	11	5.3	0.02	1.20	
5/20/2013	18	7.8	0.23	0.66	
6/5/2013	22	15.5	0.29	1.20	
6/17/2013	85	46.6	0.12	1.80	
6/27/2013	**161**	75.6	0.16	1.36	
Outfall 004					
3/5/2013	33	8.3	0.04	1.10	
3/11/2013	8	3.7	0.02	0.54	
3/18/2013	12	7.4	0.06	0.96	
3/24/2013	7	3.4	0.06	1.07	
5/7/2013	7	3.8	0.04	0.27	
5/10/2013	49	6.2	0.01	0.18	
6/10/2013	26	12.5	0.01	0.05	
6/17/2013	47	12.6	0.15	1.46	
6/27/2013	63	21.0	0.10	0.48	

* Indicates measurements taken after installation of the weir.

As can be seen in **Figure 4.1**, before the installation of the weir there was consistently seen a ‘build-up’ of sediment concentration in the flow before reaching a peak concentration and then falling back off. This is the expected response for a system where sediment builds up in a retention or detention basin during rainfall events, with the concentration in the outfall water increasing and then falling back off. What is seen after the weir installation is an immediate peak of TSS concentration in conjunction with rainfall events (**Figure 4.2**), which is indicative of localized soil disturbance.

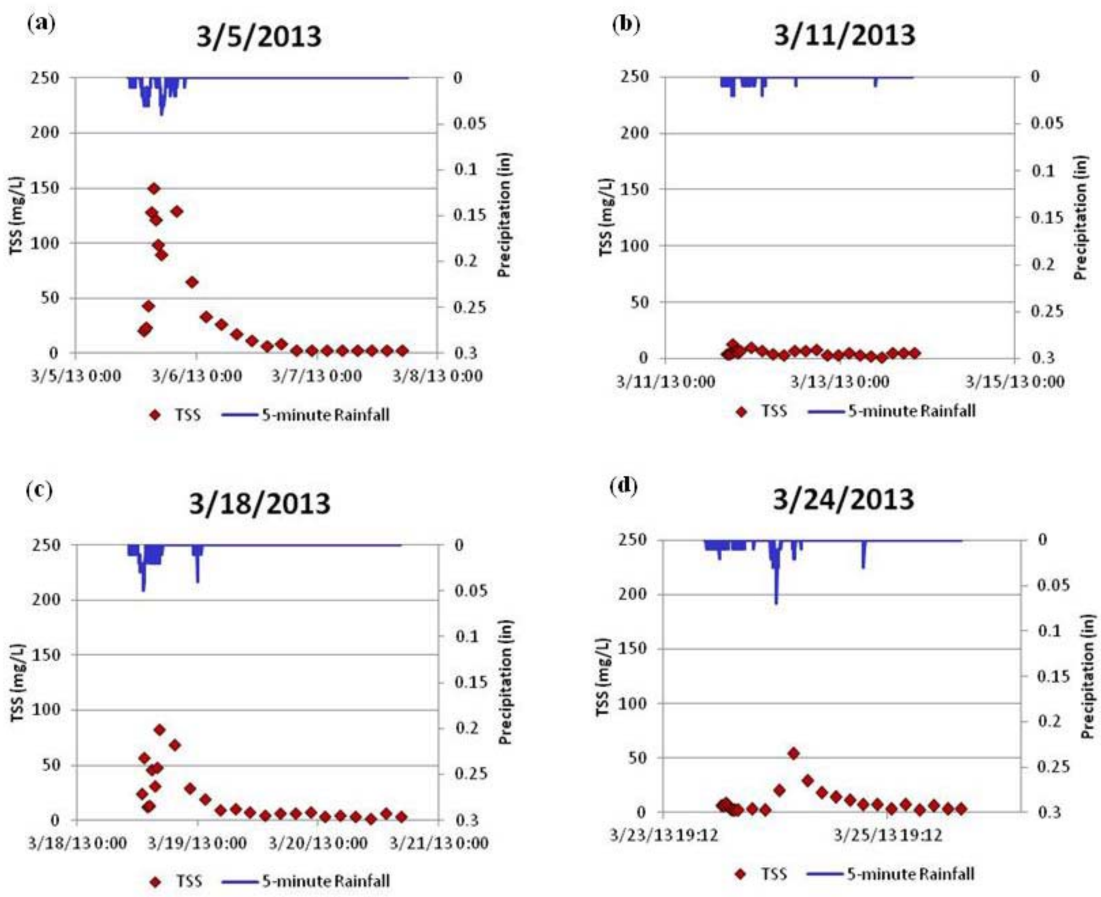


Figure 4.1. Total suspended solids (TSS) and 5-minute rainfall for the four monitored storm events prior to the installation of the weir.

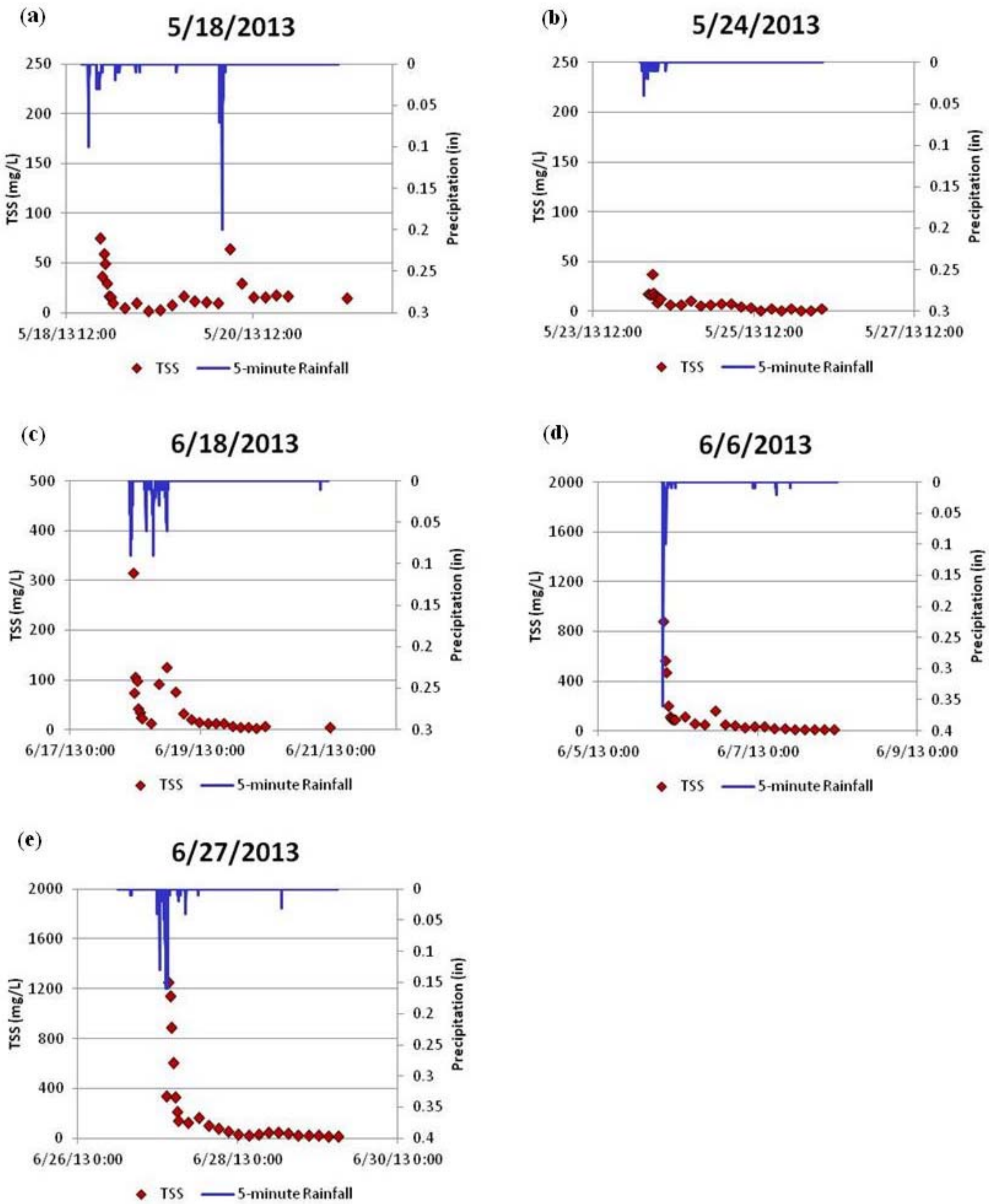


Figure 4.2. **Total suspended solids (TSS) and 5-minute rainfall for the five monitored storm events after installation of the weir.**

During the weir installation, an earthen berm was created to hold back the water flowing from the outlet. This obstruction was removed after installation of the weir was completed, however, the monitoring site at which all of the sediment samples were taken was located between the berm location and the weir. Changes in the response in TSS to rainfall events in the watershed indicate that the land disturbance associated with the construction and removal of the temporary berm have impacted the TSS measurements being taken at outfall A. As the TSS concentrations measured after the installation of the weir include sediment from local disturbance as well as sediment being carried out of the storm pond, it is recommended that the data from these sampling events be viewed as questionable.

One goal of this effort was to assess the usefulness of historical DMME monitoring of permitted discharges in representing existing TSS conditions. **Table 4.3** shows a comparison of DMME data to data collected during this study. As would be expected, the DMME averages are higher than the baseflow grab samples collected during this study, but lower than the average maximum TSS values collected during storm events. For Outfalls 004 and B, the DMME data is close to the average storm TSS recorded. However, for Outfall A, the DMME value is considerably less than the average storm TSS. In order to account for possible effects from the weir installation, the pre-weir data was assessed separately. The average storm TSS for Outfall A using these data is more comparable to the DMME data, however, the values at the other two outfalls (not impacted by the weir installation) also drop significantly, indicating that the storms monitored after the weir installation had a greater impact on TSS delivery.

Table 4.3 Comparison of DMME long-term monitoring to storm-event monitoring.

Data Source	Outfall 004 TSS (mg/L)	Outfall A TSS (mg/L)	Outfall B TSS (mg/L)
DMME Monitoring [1]	8.4	8.5	19.8
Baseflow Average [2]	6.0	4.2	6.3
Average Storm Max [3]	28	319	44
Average Storm [4]	9	60	22
Average Storm Max: Pre-Weir [5]	*15*	*75*	*24*
Average Storm: Pre-Weir	*6*	*20*	*12*

[1] "DMME Monitoring" data are flow-weighted averages based on all available permit compliance monitoring data.
[2] "Baseflow Average" represents the average of the TSS values recorded for during baseflow conditions.
[3] "Average Storm Max" represents the average of the maximum TSS values recorded for each storm.
[4] "Average Storm" represents the average of all TSS values recorded for during storms.
[5] "Pre-Weir" indicates that only data collected prior to the weir installation were used.

5. RECOMMENDATIONS

The data available from this monitoring effort is limited, however, it does provide insight toward answering the two questions stated earlier in this report.

- What is the best approach for representing existing contributions from permitted mining discharges?
- What is the best approach for representing allocated loads from permitted mining discharges?

As stated earlier, two approaches have been used for modeling these discharges (*Traditional* and *Proposed*). These recommendations will examine each, in light of the additional data that the monitoring proveds.

5.1 Existing Permit Loads

Both the *Traditional* and *Proposed* approaches calculate a load that is intended to represent long-term, average conditions across the broad spectrum of climate and land use circumstances that are encountered among permitted dischargers. The *Traditional* approach accomplished this by using long-term monitoring data to calculate flow-weighted average TSS concentrations, and apply them to flow volumes modeled from active mine areas. These long-term average concentrations are, typically, less than the permitted 70 mg/L. **Table 4.3** showed how this approach compared to the storm event data that was monitored during this effort. Keeping in mind that the goal is to provide a long-term average representation of varied conditions, this approach may be reasonable, but, arguably may be biased a bit low, particularly as compared to the "worst-case" scenario of Outfall A.

The *Proposed* approach calculated a load based on modeling conditions in the permitted areas (extractive, reclaimed, and released). This approach yields an annual sediment load from each land use, an annual runoff volume from each land use, and annual groundwater volume that is delivered to the stream. Using these values from the Bull Creek TMDL, a long-term average TSS concentration was calculated at greater than 2,000 mg/L. While it is conceivable that a peak TSS concentration could reach this level, based on the monitoring effort conducted for this study, it is, arguably, too large a concentration to represent long-term, average conditions.

The *Traditional* approach appears to be potentially biased low, while the *Proposed* approach appears to be biased high. A reasonable compromise, based on this monitored data, would be to model the existing load from permitted mine sources at the permitted level of 70 mg/L. This value is higher than the average storm event concentrations calculated for each site (**Table 4.3**), and is arguably a conservative estimate for the long-term average condition. This concentration should be applied to the average annual flow volume from disturbed areas to estimate the existing TSS load.

5.2 Allocated Permit Loads

Both the *Traditional* and *Proposed* approaches use the permitted TSS concentration (70 mg/L) to calculate the allocated permit loads. The *Traditional* approach applies this concentration to the average annual flow volume from disturbed areas to estimate the allocated TSS load. The *Proposed* approach applies this concentration to the average annual flow volume from all permitted areas. While the *Proposed* approach represents the "worst-case" scenario in terms of water quality, where all permitted mine areas within a watershed are disturbed at the same time, it does not represent a "typical" scenario. In fact, this condition has not been seen during any known TMDL development. Since surface mine operators are only permitted for discharge from storm ponds, as compared to all runoff from permitted areas whether actively being mined or not, and since mine operators only install ponds in conjunction with mine operations, TSS loads associated with runoff from non-disturbed lands should remain in the load allocation (LA), rather than the waste load allocation (WLA). While this may be somewhat limiting to the mine operators, it is protective of water quality.

5.3 Conclusions

In the current state of knowledge, regarding TSS delivery from surface mine operations, the following recommendation is offered.

- Both existing and permitted conditions should be modeled at the permitted level of 70 mg/L. This concentration should be applied to the average annual flow volume from disturbed areas to estimate TSS loads.